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Agricultural Engineering Education in Developing and Transition Countries*

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To serve the economic development needs of developing and transition countries, two distinct 'agricultural engineering' curricula are proposed. One to educate bio-process engineers and the other to educate engineering technologists. The bio-process engineers are expected to create innovative products that meet market expectations and to solve complex and diverse processing problems. It is suggested that the on-farm needs of agriculture are best met by a specialisation in agricultural engineering technology. An agricultural engineering technologist is a broadly educated agriculturalist with the ability to solve straightforward engineering problems through application of proven systems.

Keywords: bio-process engineering; agricultural engineering technology; curricula

INTRODUCTION

THIS PAPER assumes, as fact, that the ability to create, utilise and manage the engineering systems required to deliver food and agricultural products to consumers and users is one of the pivotal elements in the advancement of developing and transition countries. Thus, the public and private sectors of such countries must have access to suitably educated young engineers if economic growth is to occur.

The educational objectives of the degree programmes must address the perceived needs of developing and transition countries in circumstances where the public sector has limited capacity and there is a critical need to build the engineering capacity of the private sector. The objectives have to attend to the requirements of small and medium scale enterprises throughout the value chain for food and agricultural products. They must focus on the need to increase the cost and quality competitiveness of these enterprises through application of appropriate engineering systems and to build reliable linkages within the value chain for small-holder farmers and small agro-enterprises enabling them to benefit from market opportunities. The single factor linking all parts of the agri-food system is the development of new and improved products.

The paper begins by briefly placing engineering systems in the context of the drivers of economic growth. The issues confronting engineering educators in developing and transition countries are explored, then an alternative education model for agricultural engineering is proposed. The objectives of two degree programmes are listed.

CATALYSTS FOR ECONOMIC GROWTH

The suggestions concerning agricultural engineering education that are put forward in this paper are predicated on three assumptions. First, in the 21st century, economic growth remains the primary objective of governments across the globe. However, disagreement exists regarding the most appropriate means of achieving it. Furthermore, there is significant debate as to the best practices to foster economic advancement in developing and transition countries. For the purposes of this paper the conclusions to be drawn from the debate are not, in and of themselves, important. Rather, what is important is to acknowledge that trade is important; whether that trade occurs within domestic, regional or global markets is also of less significance. What is critical is to acknowledge that trade only occurs when a product enters a market and is sold, or in other words, it is traded. Thus, the first assumption is that economic growth cannot occur unless products are delivered to a market which demands those products and they are purchased.

Second, it is recognised that over the next 25 years it will become harder to sustain the momentum of trade liberalisation (World Bank 2000). Furthermore, spatially, rural and agricultural development has been uneven and often inequitable, such that perhaps as many as one person in five lives in a world where food is plentiful, yet it is denied to them (Conway 1997). According to Pingali (2002), even though the private sector is expected to play an increasingly important role in the dissemination of technology in the developing world, it will not cater for the needs of small-scale and subsistence farmers. The need for investment in public goods that enhance the productivity of marginalised households continues to be urgent. Therefore, it is assumed that there will be a continuing need for appropriate technical support for small-scale and subsistence farmers.

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Third, it is assumed that the development, production and delivery to the consumer of agricultural and food products involve engineering systems. Therefore, the ability to create, utilise and manage such engineering systems to develop new and improved products that meet the needs of markets is pivotal to economic development.

MEETING THE NEEDS FOR ENGINEERS

If product development is a catalyst for economic growth and if product development requires engineers then regions where economic growth is occurring should provide useful guidance to other developing and transition countries. Hof [4], argued in an article in *Business Week* that '. . . now more than ever, innovation is the answer; jobs will arise from the creation of new products, processes, and markets . . .' *The Bangkok Post* [8], reported that the Thai Industry Ministry had come up with seven strategies for developing Thailand's industrial sector; two of the seven were enhancing competitiveness and promoting innovation.

The dynamic economic development of Asian countries was examined by the Asian Productivity Organisation [2] to consider mismatches in the labour market. The study reported that:

> Asian countries are at different stages of economic development, their industrial structures vary accordingly, and thus social circumstances surrounding the surveyed enterprises are very different. Changes in social circumstances influence the employment practices of enterprises and they are partly responsible for unemployment and underemployment.
>
> Enterprises seek personnel with abilities and skills different from the conventional ones in an attempt to cope with the influence of changes in social circumstances. However, it is difficult for them to attract and retain personnel of high quality, and there is a gap or mismatch between the qualities and abilities that enterprises require and those that employees actually have. Such gaps exist not only in developed countries such as Japan, the Republic of China, and Singapore, but also in many developing countries where the gaps are widening.

One interesting effect, that has been most notable in the information and communication technology (ICT) sector, has been the transfer of jobs from developed, high cost, economies to developing, lower cost, economies. In practice this first occurred with manufacturing jobs, but it has now moved to 'knowledge-intensive' positions in software and in some cases, research and development. (McGraw [5], discusses this phenomenon in the context of US-based engineering curricula.) The growing interest in this dimension was reflected at the eleventh conference of UNCTAD (Sao Paolo, Brazil, June 2004) during which the topic of foreign direct investment in developing and transition countries was debated. The importance of job creation and enhancing productive capacity was highlighted.

Engineering educators in developing and transition countries find themselves facing a daunting conundrum. On the one hand they are usually poorly resourced, unable to attract sufficient numbers of academic staff, and faced with burgeoning student numbers [1]. On the other hand they are expected to produce world-class graduates to assist to attract global companies to establish operations in their country while simultaneously providing graduates that meet the needs of local businesses and agencies supporting the poor such as subsistence farmers. The needs of global companies are often incongruent with the needs of local businesses that employ a different level of technology and serve different markets.

It is clear that in many cases the outcomes for both industry and educators are sub-optimal. Too often there is a mismatch between industry needs and graduates through [2]:

- institutions of education and training not adapting to changes in society and hence industry needs;
- deteriorating quality and relevance of graduates as resources committed to education institutions dwindle;
- education and training for those already employed fails because of tradition or social bias;
- government, industry and educators fail to communicate and share information.

In summary, there is a significant challenge to match industry needs and graduate's skills and abilities in a number of countries, and failure to achieve a match has the potential to constrain economic growth.

AN EDUCATION MODEL FOR AGRICULTURAL ENGINEERING

In the context of developing and transition countries, is there a need for a specialised agricultural engineering curriculum? The agricultural engineering curriculum has traditionally been focused at the production level, that is, on-farm engineering issues (see [6] for a historical perspective on agricultural engineering education research). However, many commentators now view the process of delivering food and agricultural products to a consumer as a system. Thus, the supply of farm inputs, the on-farm production of crops and animals, the post-farm processing, and all subsequent storage, handling, and transport to deliver the product to the consumer constitute the agri-food system.

In this manuscript, a distinction is made between an agricultural engineer and an agricultural engineering technologist. An agricultural engineer is expected to create innovative solutions to complex and diverse problems in a holistic way taking market needs, environmental, community and social issues into account. Their work is based on science applied with judgement and skill and incorporates management techniques, the principles of economics and the concept of sustainability. By contrast, an agricultural engineering technologist is a broadly educated agriculturalist with the ability to solve straightforward engineering problems through application of proven systems. (For more information on the criteria by which the education programmes for an engineer and an engineering technologist are evaluated see the ABET criteria at www.abet.org.)

Thus, in this new reality, does industry want an engineer with a narrow on-farm focus or is it that the farm engineering inputs can be provided by an engineering technologist able to create systems from an existing array of technical solutions? Alternatively, has the term agricultural engineering, or its variants (see [6]) evolved to respond to the needs of modern agri-food systems? It is the author's view that the dictates of economic growth require application of the greatest intellectual skills in engineering in the area of processing biological materials to create new and improved products that meet market demands. The needs of small-scale agro-industries and farmers are best met by graduates educated to apply existing technology in pragmatic circumstances.

The fact that most university systems in developing and transition countries are resource poor imposes the need for focus and the pursuit of economies of scale. In light of this reality coupled with the clarity that the market focused agri-food systems thinking brings, it is argued that university systems in developing and transition countries give consideration to the following approaches for engineering education related to the agri-food system.

First, the curriculum of the programmes must recognise the fundamental role that new and improved products play in profitable agri-food systems. Development of new and improved products and processes should be the element that integrates the curriculum.

Second, for undergraduate education of professional engineers a minimum number of specialisations is maintained. In those countries where either the bulk of the present wealth is based on biological materials, or where the greatest potential for wealth creation is based on biological materials, it is suggested that there be a specialisation that includes or focuses on bio-processing. Food is often the biggest single industrial activity, but other products such as fibres, leather, pulp and paper, and pharmaceuticals can also be of major importance. Such a graduate should be able to:

- apply relevant engineering principles, techniques and design methods used at the leading edge in industry;
- demonstrate knowledge of basic and applied sciences relevant to the target industrial sector;
- apply logical and lateral thinking skills for leading constructive change through product and process innovation;
- demonstrate proficiency in industrial problem-solving methodology;
- demonstrate an ability to evaluate alternatives in technical, commercial, and social terms;
- demonstrate preliminary experience in the implementation of solutions in organisations;
- demonstrate an ability to contribute to, and lead multi-disciplinary teams working on industrial projects;
- demonstrate intellectual independence and self-learning skills by which they maintain their ongoing professional integrity.

The Bio-process Engineering specialisation should give a broad education in the principles and practice of the processing of biological materials. Areas covered should include:

- basic techniques of problem-solving and new product development;
- the design of processes and factories using modern integrated 'clean' processing techniques;
- financial analysis;
- some commercial aspects of important industries.

Third, for the education of graduates to meet the needs for on-farm engineering and technical assistance, an engineering technology program should produce graduates capable of using current technologies to develop, implement and customise equipment, processes and systems of a scale that is relevant to farmers' needs. Such a graduate should be able to:

- develop working solutions to problems by analysis, synthesis, and evaluation of existing technologies and packages of technical systems;
- apply engineering principles to the solution of technological problems;
- define information needs and appropriate data and resources to enhance farm profitability through growing new or improved products that are sought by markets;
- demonstrate general knowledge and skills relevant to the agricultural sector and to farming in particular;
- demonstrate the ability to participate in the design and development of systems, transformation processes, services and facilities;
- recognise linkages and interdependencies caused by the convergence of related disciplines within a system and the implications of proposed solutions;
- demonstrate the ability to contribute to, and lead, multidisciplinary teams seeking to transfer technology to farmers and communities.

Fourth, for the education of graduates to meet the needs of small-scale post-production enterprises, an engineering technology programme addressing the requirements of agro-processors, general manufacturers and the ICT service sector should allow economies of scale between the engineering technology specialisations.

Fifth, the implementation of such a two-tier education system relies on a high degree of focus with a minimum number of institutions delivering the programmes. The engineering technology programme for agriculture must co-exist with an agriculture faculty, while the bio-process engineering programme should co-exist with food science and/or food technology programmes.

SUMMARY

It is contended that modern agriculture is best thought of as an agri-food system which includes the supply of farm inputs, the on-farm production of crops and animals, the post-farm processing, and all subsequent storage, handling, and transport to deliver the product to the consumer. Furthermore, it is argued that to achieve economic growth in the agriculture sector there must be a focus on the delivery of products to markets that desire these products. Continued competitiveness of the agriculture sector requires an on-going commitment to the development of new and improved products to meet the evolving expectations of markets. To meet the need for the engineering skills and abilities sought by industry it is proposed that the undergraduate curriculum for professional engineers focus on bio-process engineering and that the needs of farmers and small-scale processors be met through an engineering technology curriculum.

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